Feynn Labs: Project - 2

Electric Vehicle (EV) Market Segmentation in India 2025 -Report

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Team Members:

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Overview:

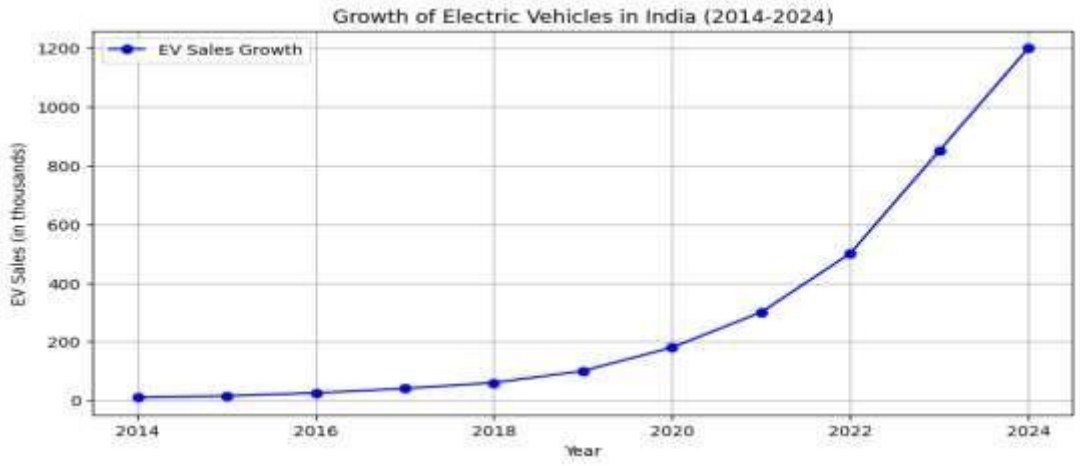
Electric Vehicles (EVs) have emerged as a game-changer in the global automotive industry, offering a cleaner and more sustainable alternative to traditional internal combustion engine (ICE) vehicles. By utilizing electric motors and drawing power from batteries, fuel cells, or external electricity sources, EVs have gained significant traction worldwide, driven by technological advancements, environmental concerns, and shifting regulatory policies.

The roots of EV technology can be traced back to the mid-19th century, but their large-scale adoption has accelerated in the 21st century. Factors such as improved battery efficiency, decreasing manufacturing costs, increased charging infrastructure, and stringent emission norms have played a key role in promoting EV usage. Governments across the world are introducing policies to phase out fossil fuel-powered vehicles and encourage electrification in the transportation sector.

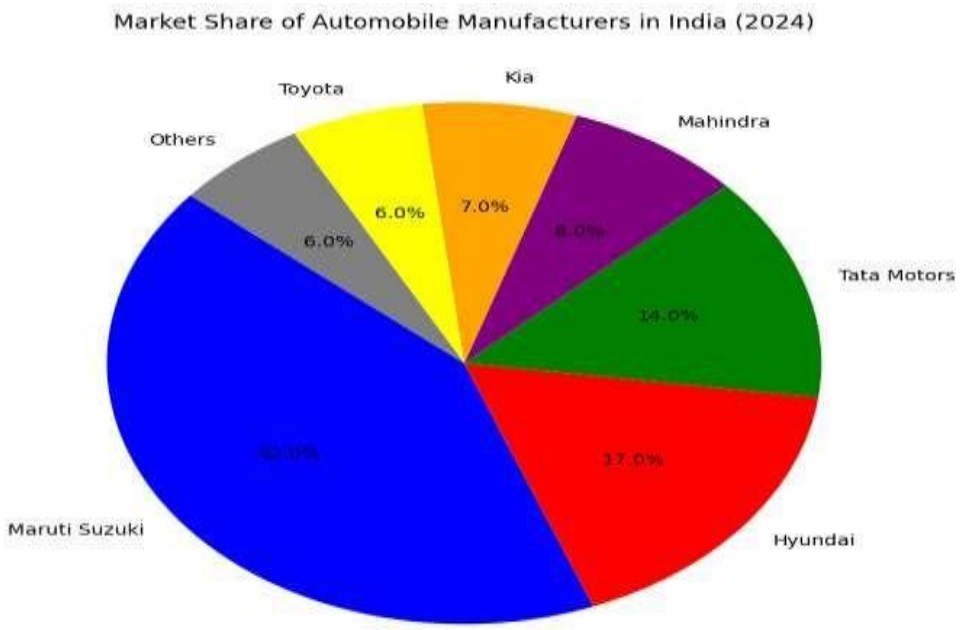
In India, the EV industry is still in its early stages but holds enormous growth potential. Currently, EVs account for less than 1% of total vehicle sales, but projections indicate a significant rise beyond 5% in the coming years. Government initiatives such as the Faster Adoption and Manufacturing of Electric Vehicles (FAME) scheme, subsidies, tax benefits, and infrastructure development are shaping the future of India's EV market. The sector is primarily dominated by electric two-wheelers, with over 5 lakh registered units, alongside a growing market for electric cars, buses, and commercial vehicles. As India moves towards a greener and more energy-efficient transportation system, continued investment in battery technology, charging networks, and supportive policies will be crucial. The transition to EVs not only contributes to reducing carbon emissions but also enhances energy security by lowering dependence on fossil fuels. With growing consumer awareness and increasing affordability, India's EV industry is poised for rapid expansion in the coming decade.

Market Overview:

The Indian EV industry is still in its early stages, with petrol and diesel vehicles dominating the market. However, rising climate concerns and global EV adoption present a strong opportunity for Indian manufacturers. Over the past decade, EV sales in India have steadily increased due to government incentives, improved battery technology, and growing consumer interest. The following graph shows the growth trend over the last 10 years.



The majority of the share is held by Maruti Suzuki, continued by the SouthKorean automobile company Hyundai. The pie chart below represents the present market share of all the major automobile manufacturers in India.



The Indian electric vehicle (EV) market was valued at USD 5 billion in 2020 and is expected to reach USD 47 billion by 2026, registering a CAGR of over 44% during the forecast period (2021-2026). The growth of EVs in India has been significantly influenced by government initiatives, changing consumer preferences, and rising environmental concerns.

Market Trends and Challenges

While the majority of India's automobile market is dominated by petrol and diesel vehicles, EV adoption is gradually increasing. The COVID-19 pandemic initially disrupted supply chains and manufacturing activities, but the sector is regaining momentum. E-commerce giants like Amazon are integrating EVs into their delivery fleets to reduce their carbon footprint. Public transport is also witnessing a shift, with cities like Bengaluru adding 90 electric buses to their fleet and planning full electrification by 2023.

Despite the growing interest, several challenges remain. The dataset indicates that EV awareness scores vary significantly across different demographic groups, with younger and high-income groups showing greater interest in EV adoption. Additionally, the density of charging stations per 100 sq km is inconsistent, ranging from as low as 3 to as high as 17 in different areas. This disparity poses a challenge for widespread EV adoption, as range anxiety remains a significant concern.

Government Policies Driving Growth

Several state governments have introduced policies to encourage EV adoption:

- **Kerala** aims to have 1 million EVs on the road by 2022 and 6,000 ebuses by 2025.
- **Telangana** has set EV sales targets for 2025, with 80% adoption for two- and three-wheelers, 70% for commercial cars (ride-hailing companies like Ola and Uber), and 40% for buses.
- **Bengaluru** has begun transitioning its public transportation fleet, with plans to go fully electric by 2023.
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Market Segmentation and Consumer Preferences

Data from the dataset suggests that EV adoption is segmented across income levels, age groups, and commuting needs:

- **Preferred EV Types:** Scooter/bikes dominate the market, followed by sedan/SUVs and commercial trucks.
- **Income Groups:** High-income consumers exhibit a greater shift towards EVs (ICE-to-EV switch rate of up to 18%), while mid-income and budget segments are gradually catching up.
- **Government Incentives:** Areas with higher government incentives show higher EV sales figures.

Market Segmentation:

Dominance of Two/Three-Wheelers

- The majority share of the EV market in India is held by two- and threewheelers.
- This dominance is due to affordability, lower operating costs, and rising fuel prices.
- Popular brands include Ola Electric, Ather, and Bajaj. **Passenger Cars Gaining Traction**
- Passenger cars hold a significant share, with increasing demand for budget-friendly EVs like Tata Nexon EV and MG ZS EV.
- The availability of government subsidies and better charging infrastructure is boosting adoption.

Commercial EV Adoption on the Rise

- Although a smaller segment, electric commercial vehicles (e-buses, electric trucks, and fleet vehicles) are gaining traction.
- Government policies, logistics companies, and ride-sharing services are driving this growth.

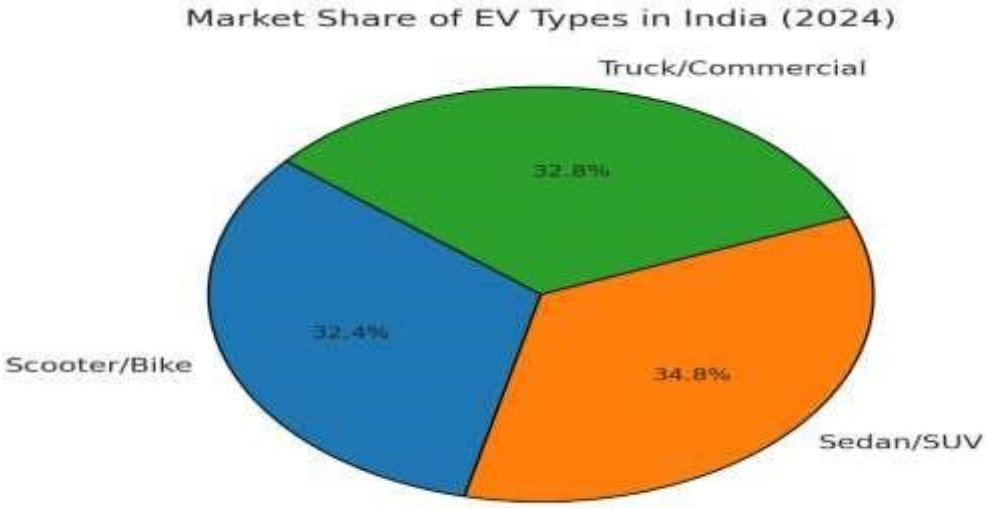
Government Push for EV Adoption

- The Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) scheme is incentivizing EV sales.

- Expansion of charging stations in metro cities is improving consumer confidence.

Future Trends

- Growth in the B2B sector (logistics, e-commerce delivery, public transport).
- Affordable financing options could further accelerate EV adoption in mid-income groups.
- Expansion of battery-swapping technology for two-wheelers and threewheelers.



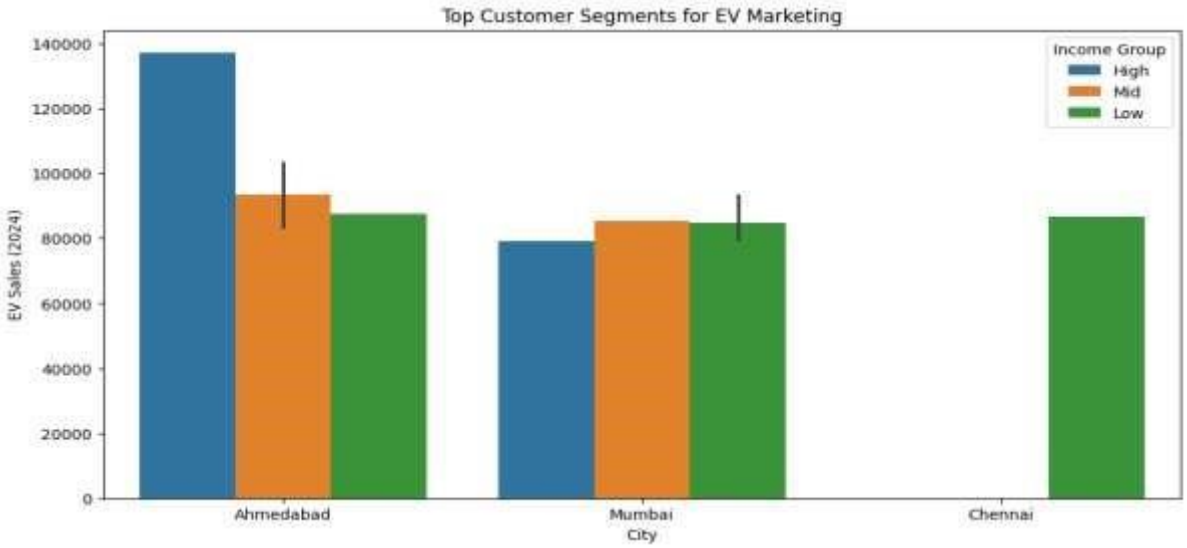
Statistical analysis:

The average daily commute is 22.6 km, ranging from 5 km to 40 km, indicating varying travel needs. EV awareness is moderate, with an average score of 7.27. Charging station density averages 11.85 per 100 sq km, suggesting infrastructure expansion potential. EV sales show strong adoption, averaging 8,168 units, with a peak of 14,996. The transition from ICE to EVs is progressing, with an average switch rate of 12.39%, reaching up to 20% in some areas.

	Daily Commute (km)	EV Awareness Score	Charging Stations Density (per 100 sq km)	EV Sales (2024)	ICE to EV Switch (%)
count	600.000000	600.00000	600.000000	600.000000	600.000000
mean	22.636667	7.27400	11.851667	8168.131667	12.399667
std	10.313677	1.29675	5.129671	4008.084382	4.430932
min	5.000000	5.00000	3.000000	1014.000000	5.000000
25%	14.000000	6.10000	7.000000	4695.750000	8.500000
50%	23.000000	7.35000	12.000000	8243.500000	12.600000
75%	32.000000	8.40000	16.000000	11587.000000	16.300000
max	40.000000	9.50000	20.000000	14996.000000	20.000000

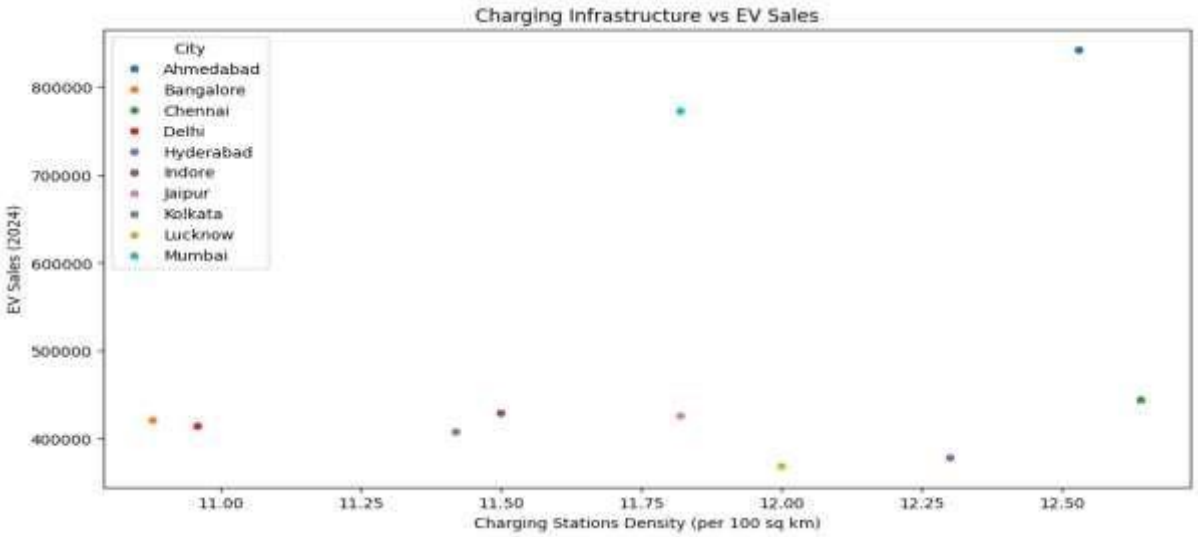
Identifying Target Customer Segments for EV Marketing

- **Ahmedabad** leads in EV sales, driven by the high-income group, with strong adoption across all segments.
- **Mumbai** has a balanced EV market, with mid and low-income groups as key buyers.
- **Chennai** sees the highest EV adoption in the low-income group, emphasizing demand for affordability.
- **Growth Potential** lies in mid and low-income segments, requiring better financing and charging infrastructure



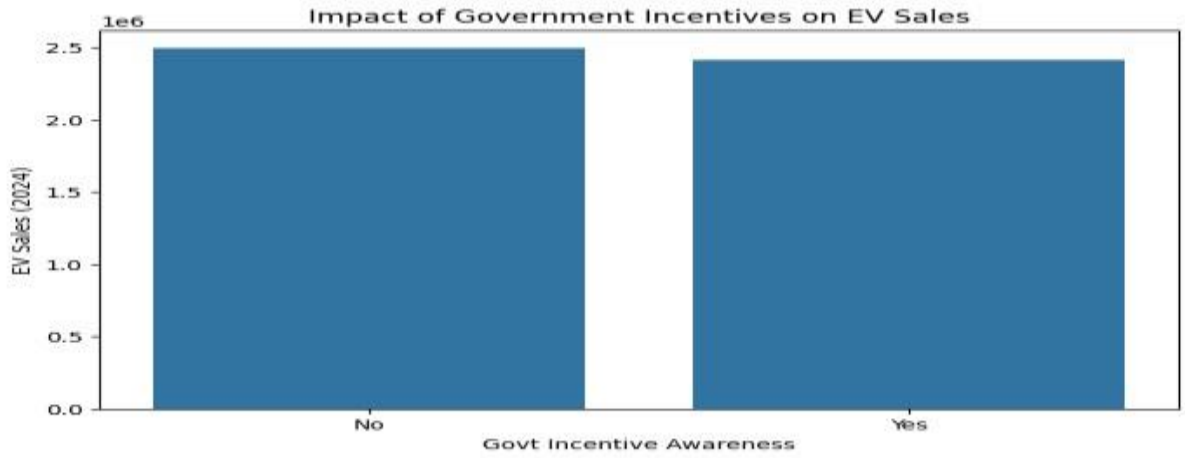
Optimizing Charging Infrastructure Deployment

- Ahmedabad and Mumbai lead in EV sales, with Mumbai having slightly lower charging density.
- Chennai has a high charging station density but lower EV sales.
- Bangalore, Delhi, and Kolkata show moderate EV sales despite varying infrastructure.
- Cities with better charging infrastructure tend to have higher EV sales.
- Lower EV sales cities need improved charging networks and incentives.



Assessing the impact of the government incentive:

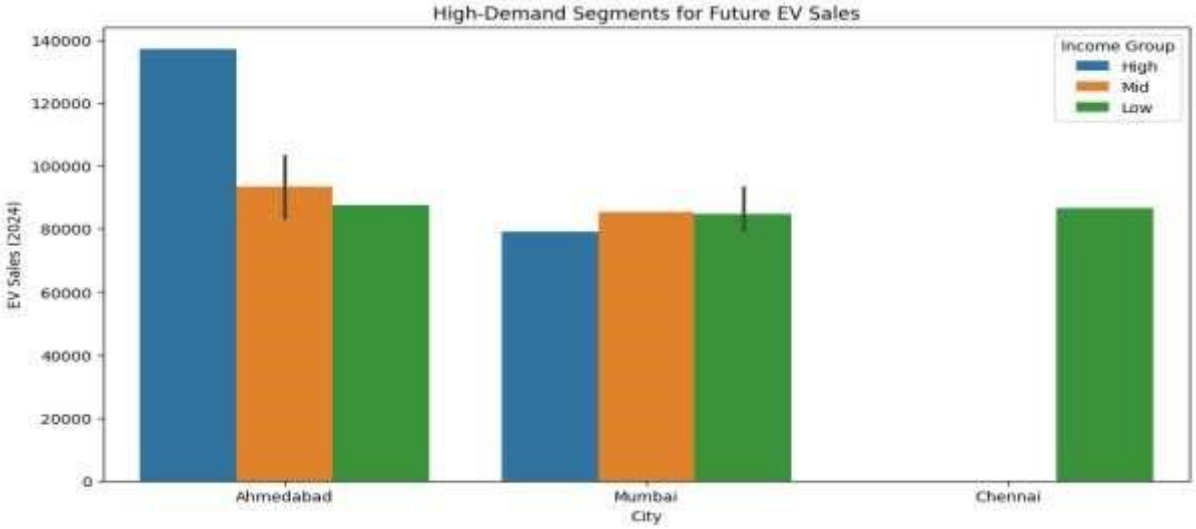
- EV sales are slightly higher among those unaware of government incentives.
- Awareness of incentives does not significantly boost EV adoption.
- Other factors may have a stronger influence on EV sales.
- Further research is needed to assess policy impact.



Predicting Future EV Demand

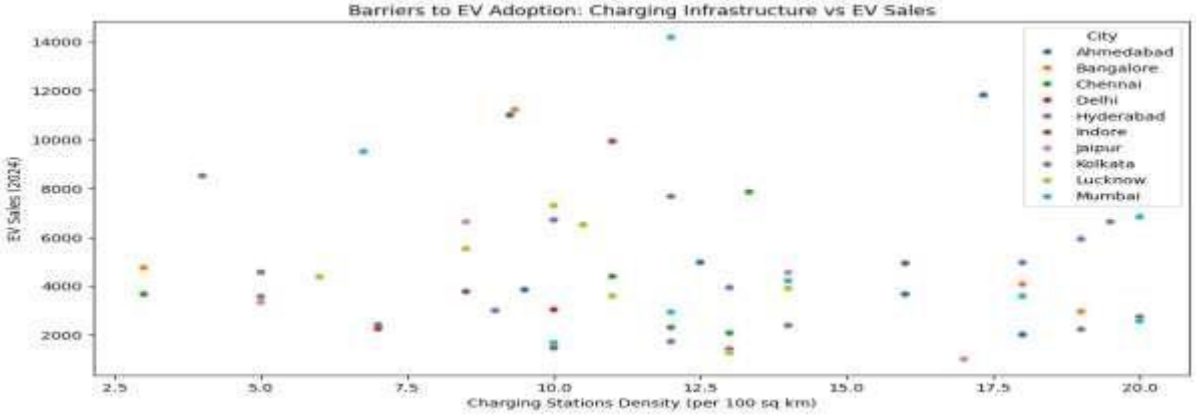
- Ahmedabad has the highest EV sales, driven mainly by high-income groups.
- Mumbai shows balanced EV sales across all income groups.
- Chennai has a strong presence in the low-income segment for EV adoption.

- Mid and low-income groups have similar EV adoption rates in Mumbai and Ahmedabad.
- Targeted policies can enhance adoption among different income groups.



Understanding Barriers to EV Adoption

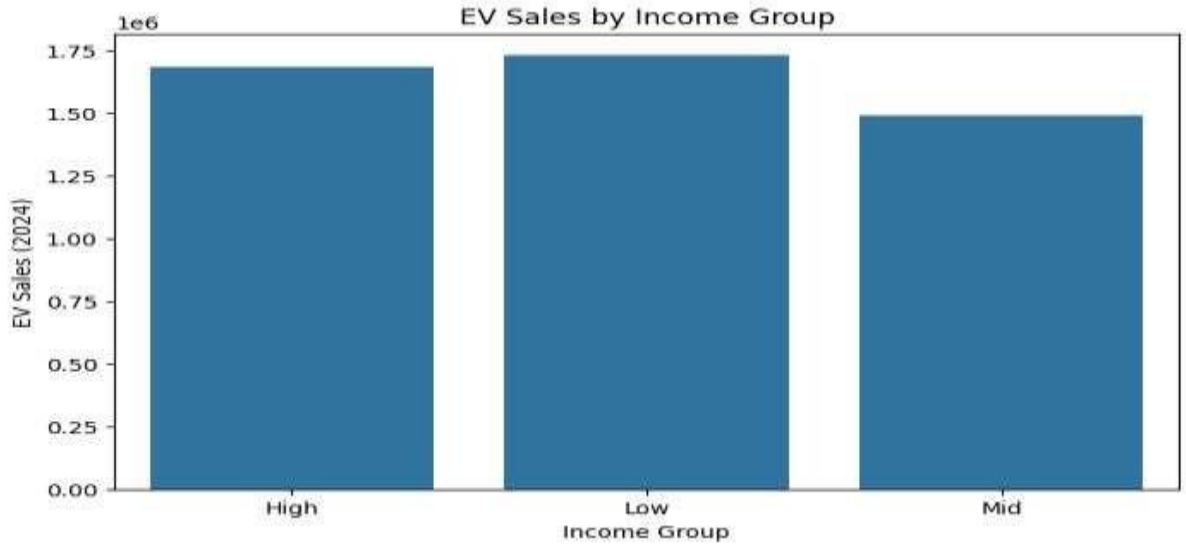
- No clear correlation between charging station density and EV sales.
- Ahmedabad and Mumbai show strong EV adoption despite different charging densities.
- Some cities with low charging density still have moderate EV sales.
- Outliers indicate other factors like policies and incentives impact adoption.
- Need for better infrastructure distribution and awareness programs.



Developing Competitive Pricing Strategies:

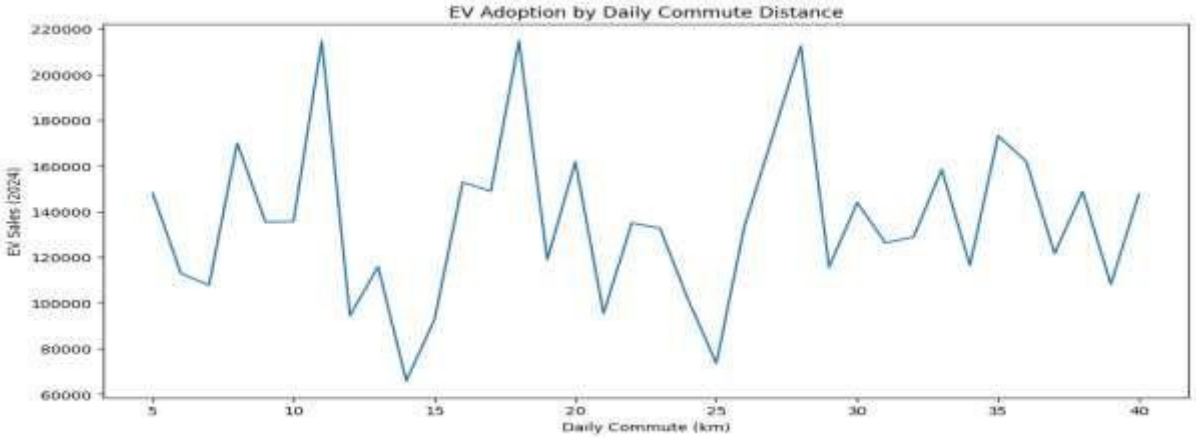
- Low-income group leads in EV sales, likely due to subsidies or affordability.
- High-income group follows, preferring premium EVs.

- Mid-income group lags, facing cost barriers and fewer incentives.
- Better financing and incentives needed for mid-income buyers.
- Further study required on low-income adoption trends.



Assessing the Impact of Daily Commute on EV Adoption:

- Fluctuating trend in EV sales across commute distances.
- Higher sales observed around 10-20 km and 25-30 km ranges.
- Sharp drops at certain distances suggest varying consumer preferences.
- Longer commutes (30+ km) still show moderate adoption.
- Further study needed on range anxiety and charging accessibility.



Clustering:

K-Means Clustering:

Clustering is one of the most common exploratory data analysis techniques used to get an intuition about the structure of the data. It can be defined as the

task of identifying subgroups in the data such that data points in the same subgroup (cluster) are very similar while data points in different clusters are very different. In other words, we try to find homogeneous subgroups within the data such that data points in each cluster are as similar as possible according to a similarity measure such as Euclidean-based distance or correlation-based distance. The decision of which similarity measure to use is application specific. Clustering analysis can be done on the basis of features where we try to find subgroups of samples based on features or on the basis of samples where we try to find subgroups of features based on samples.

K Means Algorithm:

K Means algorithm is an iterative algorithm that tries to partition the dataset into pre-defined distinct non-overlapping subgroups (clusters) where each data point belongs to **only one group**. It tries to make the intra-cluster data points as similar as possible while also keeping the clusters as different (far) as possible. It assigns data points to a cluster such that the sum of the squared distance between the data points and the cluster's centroid (arithmetic mean of all the data points that belong to that cluster) is at the minimum. The less variation we have within clusters, the more homogeneous (similar) the data points are within the same cluster.

The way k means algorithm works is as follows:

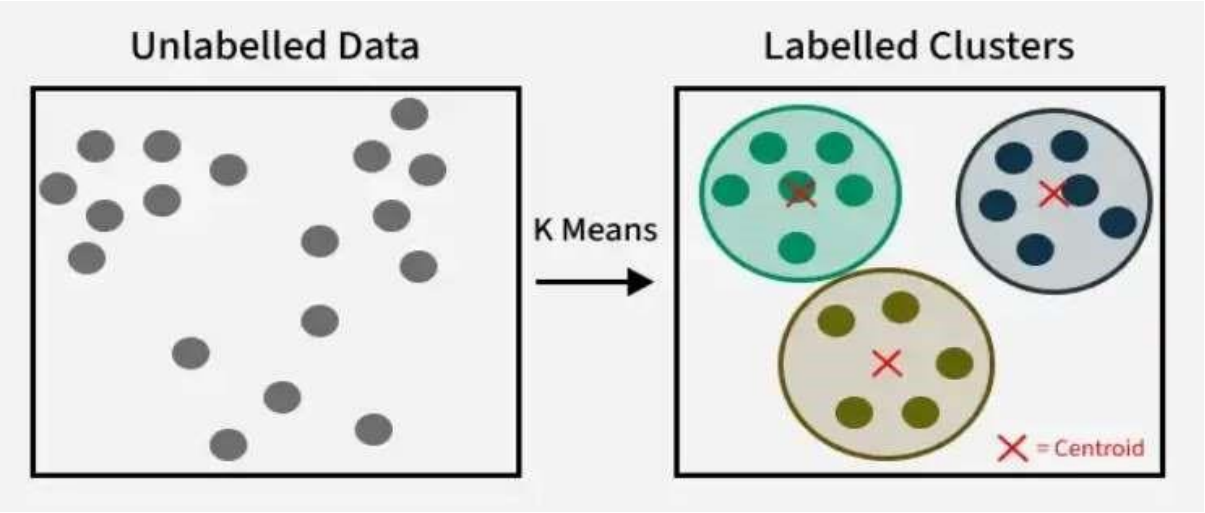
1. Specify number of clusters *K*.
2. Initialize centroids by first shuffling the dataset and then randomly selecting *K* data points for the centroids without replacement.
3. Keep iterating until there is no change to the centroids. i.e. assignment of data points to clusters isn't changing.

The approach k-means follows to solve the problem is **expectation maximization**
The E-step is assigning the data points to the closest cluster. The M-step is computing the centroid of each cluster. Below is a breakdown of how we can solve it mathematically.

How k-means clustering works?

We are given a data set of items with certain features and values for these features (like a vector). The task is to categorize those items into groups. To

achieve this, we will use the K-means algorithm. ‘K’ in the name of the algorithm represents the number of groups/clusters we want to classify our items into.



The objective function is:

The **objective function** for **K-Means Clustering** is the minimization of the sum of squared distances between each data point and its assigned cluster centroid:

$$J = \sum_{i=1}^{k} \sum_{j \in C_i} ||x_j - \mu_i||^2$$

Where:

- J = Objective function (sum of squared errors).
- k = Number of clusters.
- C_i = Cluster i.
- x_j = Data point assigned to cluster i.
- μ_i = Centroid of cluster i.
- $||x_j - \mu_i||^2$ = Squared Euclidean distance.

Applications:

K means algorithm is very popular and used in a variety of applications such as market segmentation, document clustering, image segmentation and image compression, etc.
The goal usually when we undergo a cluster analysis is either: 1. Get a meaningful intuition of the structure of the data we're dealing with. 2. Cluster-then-predict where different models will be built for different subgroups if we believe there is a wide variation in the behaviours of different subgroups.

Packages/ Tools used:

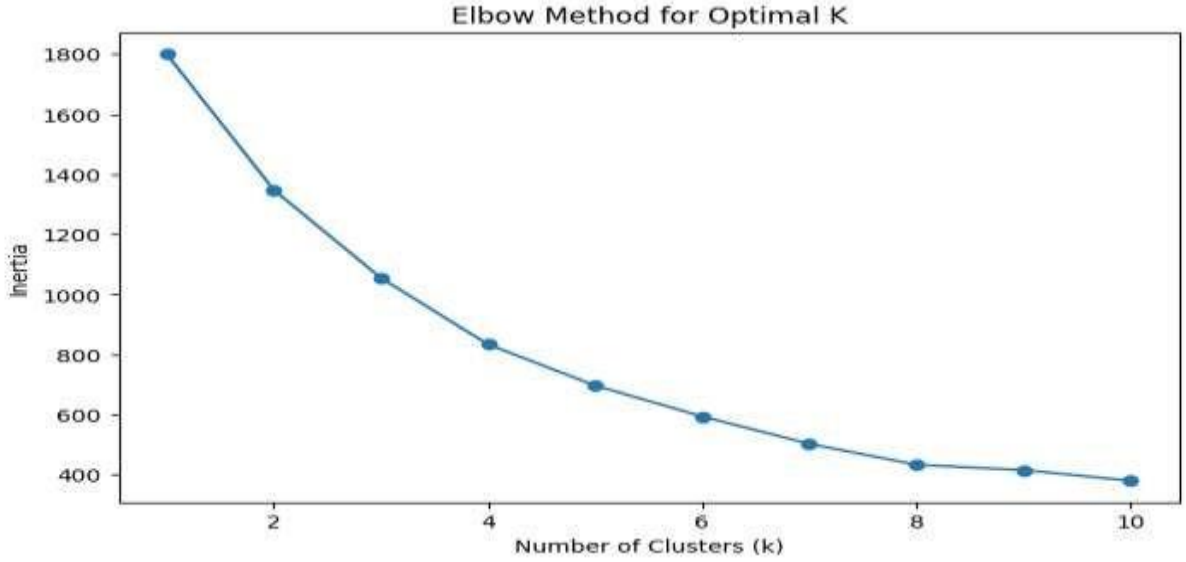
- **numpy** – Used for numerical computations, handling arrays, and performing matrix operations. Essential for data processing and clustering algorithms.
- **pandas** – Helps in data manipulation and analysis, enabling efficient handling of structured data like sales records, EV awareness scores, and customer preferences.
- **matplotlib** – A visualization library used for creating 2D and 3D plots, such as scatter plots for EV awareness vs. daily commute.
- **seaborn** – Built on matplotlib, this library enhances statistical data visualization with attractive and informative graphs. Ideal for clustering analysis and correlation heatmaps.
- **scikit-learn** – Provides machine learning tools for clustering (like KMeans) and other predictive analytics, crucial for understanding customer segments.

We have considered a dataset which contains data regarding the spending habits of people regarding type of cars etc.

K-Means Clustering for Customer Segmentation:

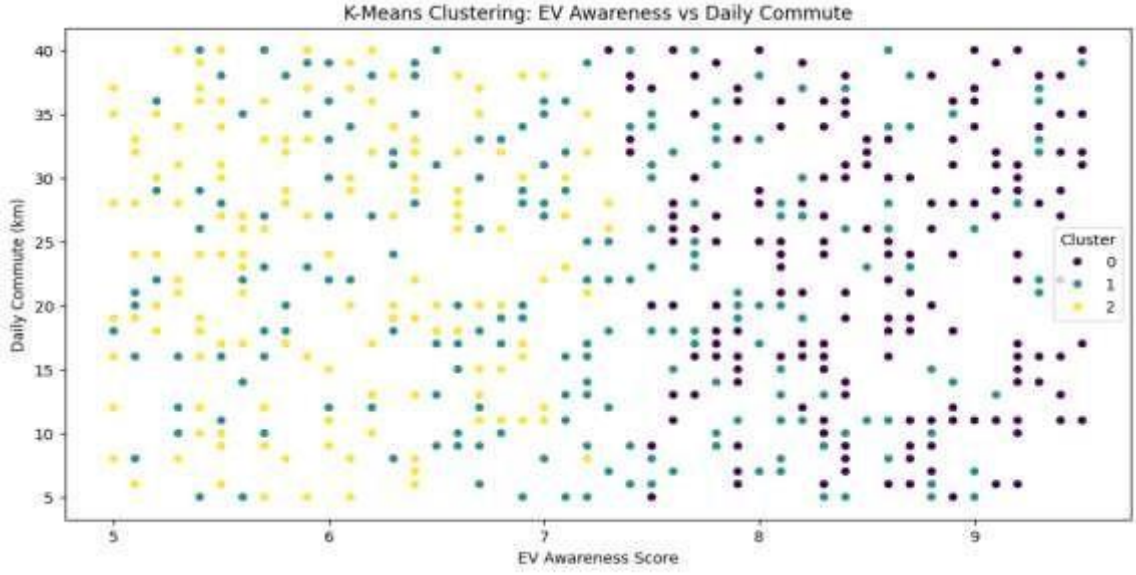
Elbow Method Key Points

- Purpose: Finds the optimal number of clusters (K) in K-Means.
- Interpretation: The "elbow point" is where inertia stops decreasing sharply.
- Observation: Best K is around 3 or 4 based on the graph**.**



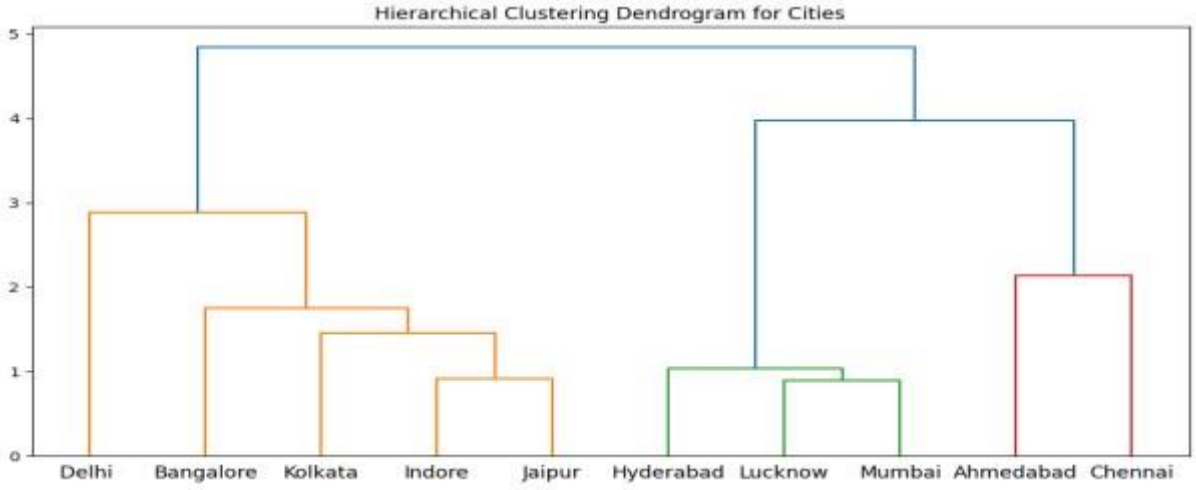
Objective: Segment individuals based on EV awareness score and daily commute distance using K-Means clustering.

- **Cluster 0** (Purple): High EV awareness, moderate commute.
- **Cluster 1** (Teal): Moderate awareness, varied commute.
- **Cluster 2** (Yellow): Low awareness, shorter commute.



Hierarchical Clustering for City Segmentation

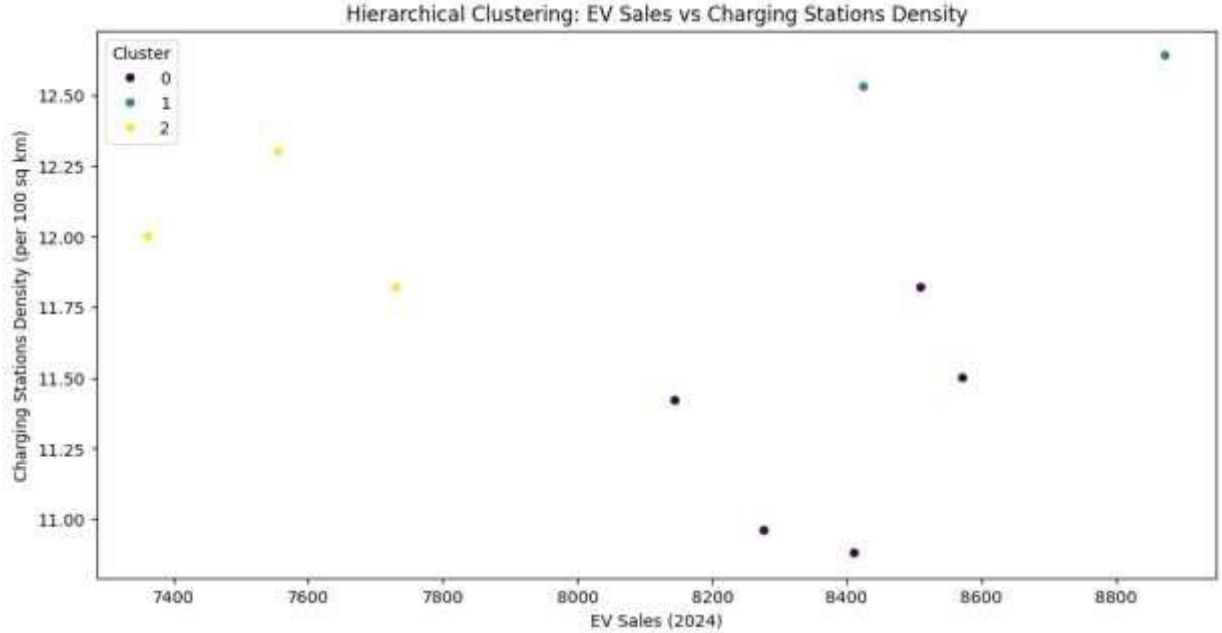
- **Purpose:** Shows hierarchical relationships between cities based on similarity.
- **Interpretation:** The height of the vertical lines indicates cluster distances.
- **Observation:** Three major clusters are visible, indicating distinct groups.



Hierarchical Clustering on EV Sales vs Charging Stations Density:

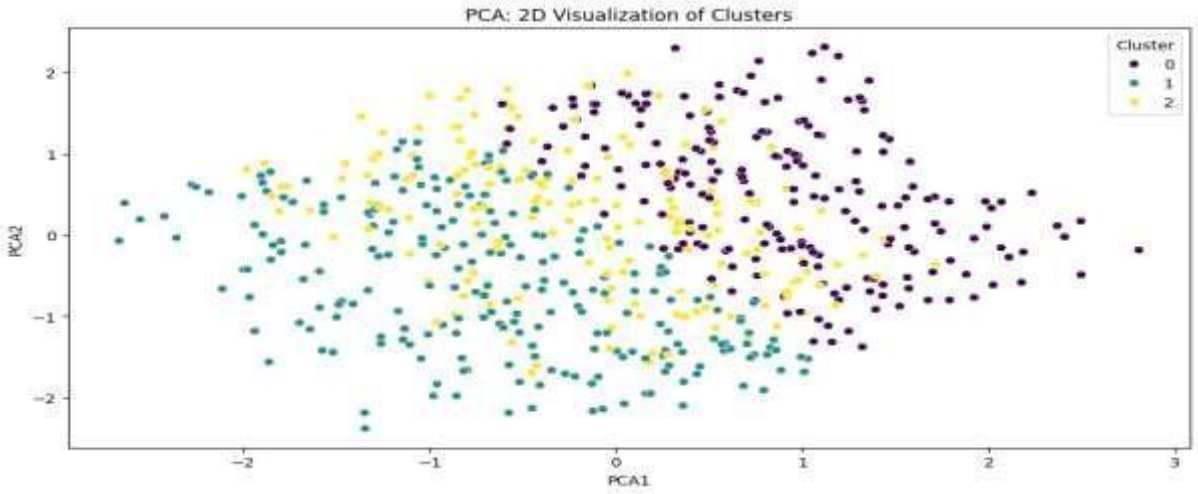
Cluster 0 (Purple): Mid EV sales, low charging density.
Cluster 1 (Blue): High EV sales, moderate charging density.
Cluster 2 (Yellow): Low EV sales, high charging density.

- **Insight:** Highlights the relationship between EV adoption and infrastructure.



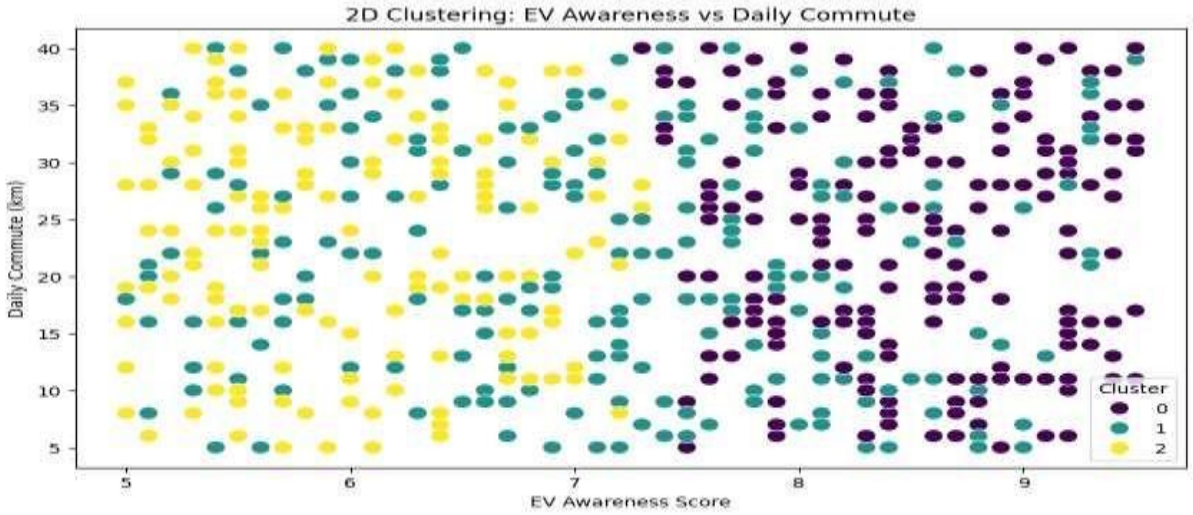
PCA For Dimensionality Reduction and Visualization:

- Cluster Distribution: Cluster 0 (purple) is dense, Cluster 1 (teal) is widely spread, and Cluster 2 (yellow) overlaps with others.
- Separation & Overlap: Some clusters show distinct separation, while others have overlapping points.
- PCA Effectiveness: PCA reduces dimensionality while preserving variance but may not fully separate clusters.
- Potential Improvements: Techniques like t-SNE or UMAP can enhance visualization and separation.



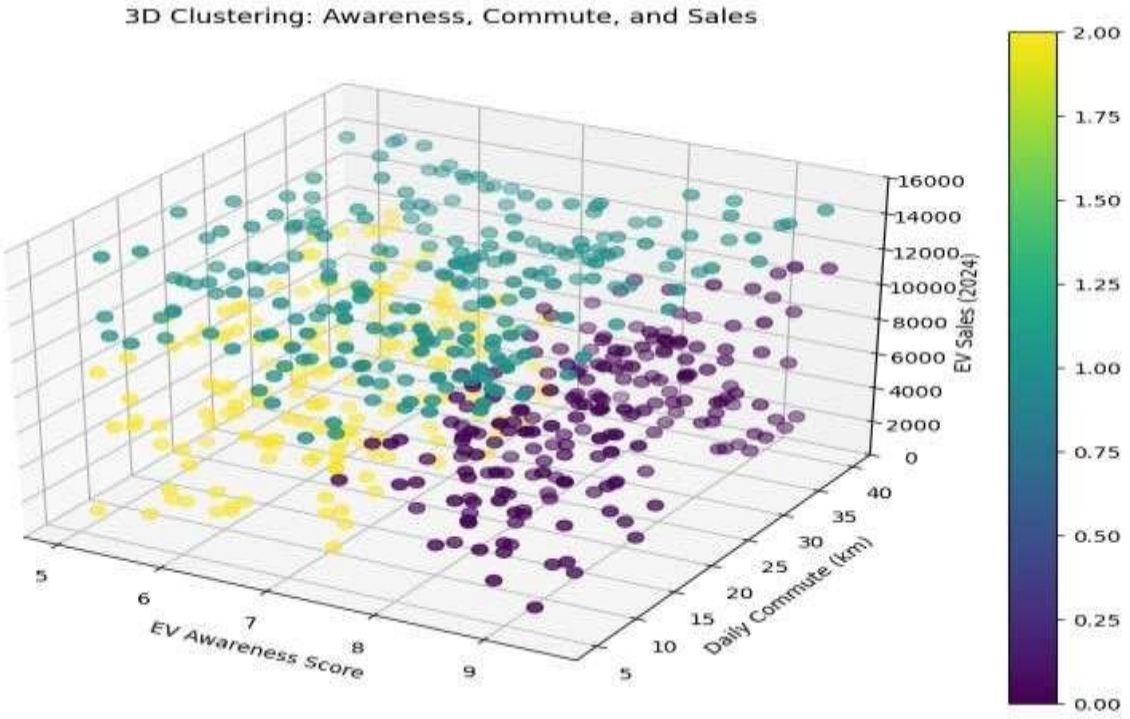
2D Scatter Plot (EV Awareness vs Daily Commute):

- Cluster 0 (purple) is concentrated at higher EV awareness scores.
- Clusters 1 (teal) and 2 (yellow) are scattered across different commute distances.
- Higher EV awareness (score >8) mostly corresponds to Cluster 0.



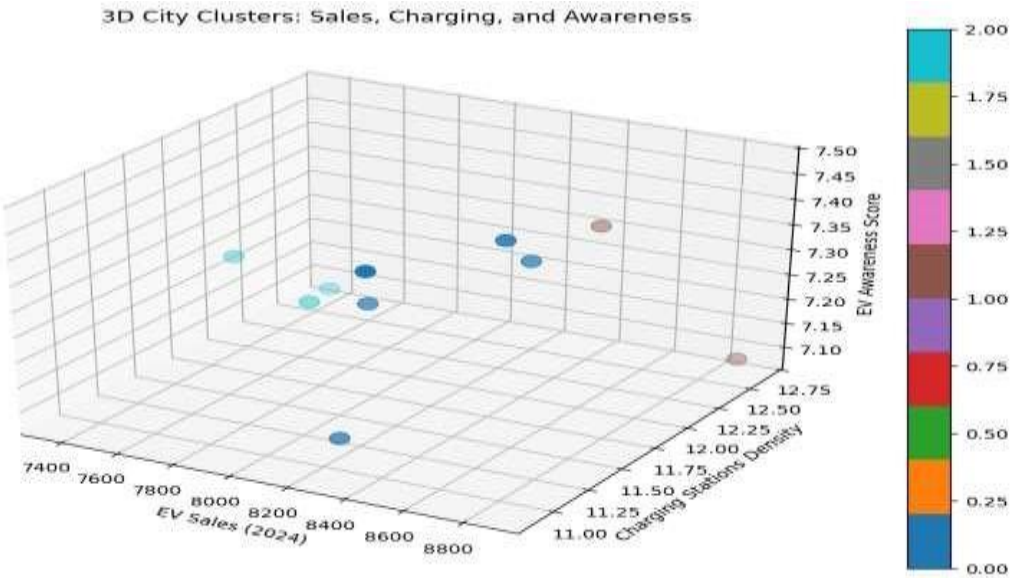
3D Scatter Plot (EV Awareness, Commute, Sales):

- Higher EV awareness scores are associated with increased EV sales.
- Clusters show distinct patterns, with the yellow group concentrated at lower awareness scores.
- Daily commute distance impacts clustering, with longer commutes seen in diverse clusters.



3D Scatter Plot (EV Sales, Charging Density, Awareness):

- Cities with higher charging station density tend to have higher EV sales.
- EV awareness scores vary across clusters, influencing adoption trends.
- The distribution suggests a correlation between infrastructure availability and EV market growth



4Ps of Marketing Mix:

The marketing mix framework, originally known as the 4Ps, has evolved into the 7Ps model to address the complexities of modern digital marketing. A wellstructured marketing mix is crucial for companies to evaluate and refine their strategies for introducing and sustaining products in a competitive market. The effectiveness of marketing relies on considering all elements of the mix holistically, ensuring a seamless and consistent customer experience.

Significance of the Marketing Mix:

- It helps businesses define and position their product effectively in the market.
- Assists in strategizing, developing, and implementing impactful marketing campaigns.
- Enables companies to assess whether their offerings align with customer expectations and market demands. •

Key Elements for EV Market Strategy:

- **Product:** Since electric vehicles (EVs) are relatively new to the Indian market, factors like battery efficiency, charging time, mileage per charge, and acceleration impact customer perception. Building trust in technology and performance is key to adoption.
- **Price:** Pricing strategies should be tailored to India's diverse economic landscape rather than directly adopting global benchmarks. Affordability and financing options will play a significant role in mass adoption.
- **Place:** The availability and distribution of EVs depend on government incentives, infrastructure support, and localized policies that promote sustainable mobility.
- **Promotion:** Marketing campaigns should be data-driven, targeting customer segments most likely to adopt EVs. Offering tailored incentives, discounts, and financing options can accelerate market penetration.

My GitHub:
https://github.com/niranjan-vini/ev_market_segment_anaylsis